MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2015/2016

EMG2016 – ELECTROMAGNETIC THEORY

(All Section / Groups)

7 OCTOBER 2015
2:30 P.M- 4:30 P.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. Each question carry equal marks and the distribution of the marks for each question are given.
3. Please write all your answers in the Answer Booklet provided.
4. In case Smith Chart is used, please tear it off, and attach the used one(s) with the answer script.

Question 1

(a) A telephone line operates at 10 MHz and has the following parameters:

R = 40 Ω/m, G = 400 μS/m, L = 0.2 μH/m, C = 0.5 nF/m

Calculate:

(i) The characteristic impedance.

[5 marks]

(ii) The phase velocity.

[5 marks]

(b) A 50 Ω lossless line is 4.2 m long. At the operating frequency of 300 MHz, the input impedance at the middle of the line is 80-j60 Ω. Assuming $u = 0.8c$, Find:

(i) The input impedance at the generator.

[9 marks]

(ii) The voltage reflection coefficient at the load.

[6 marks]

Question 2

(a) A conducting rod of length l rotates about the z-axis with an angular velocity ω. If the magnetic field B = $B_o\, a_z$, calculate the voltage induced on the conducting rod.

[8 marks]

(b) A square loop of side a recedes with a uniform velocity $u_o\, a_y$ from an infinitely long filament carry current I along a_z as shown in **Figure Q2**. Assuming that $b = b_o$ at time $t = 0$, calculate the emf induced in the loop.

[10 marks]

(c) Proof that $\underline{\nabla} \cdot \underline{J} = -\dfrac{\partial \rho_v}{\partial t}$

[7 marks]

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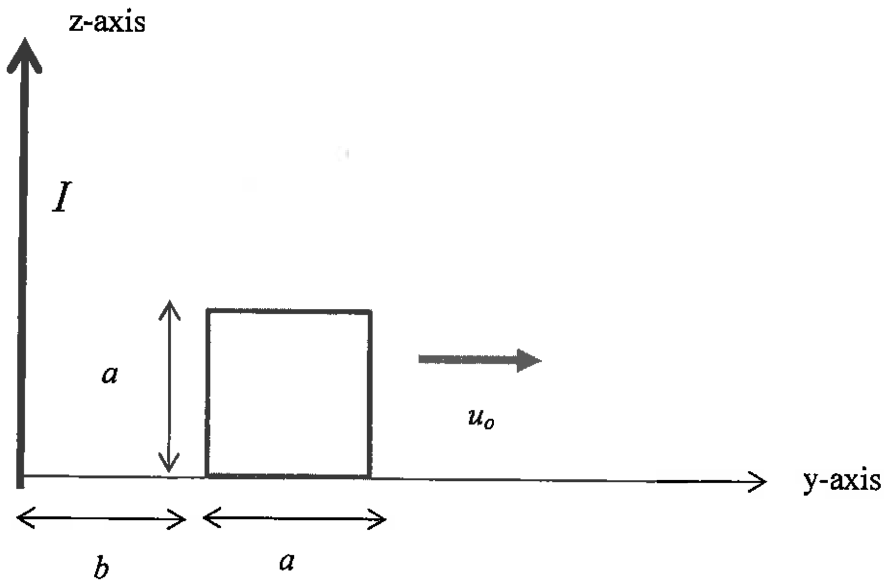

Figure Q2

Question 3

(a) A 100MHz uniform plane wave propagates into a polyethylene medium. The amplitude of the electric field intensity is $\widetilde{E}(z,t) = 30e^{-\gamma z}\hat{x}$ V/m and the material is assumed to be lossy with $\varepsilon_r = 2.3\varepsilon_0$, $\mu_r = \mu_0$ and $\sigma = 0.2S/m$.

Calculate:

(i) Complex propagation constant, γ, attenuation constant, α and phase constant, β.

[4 marks]

(ii) Wavelength, λ of the propagating wave.

[2 marks]

(iii) Phase velocity, $u_{p.}$

[2 marks]

(iv) Intrinsic impedance, η of the medium.

[2 marks]

Hence, state whether the material is a low loss dielectric material or a good conductor.

[2 mark]

Continued…

(b) A 50 MHz right-hand circularly polarized plane wave with an electric field modulus of 30 V/m is normally incident in air upon a dielectric medium with $\varepsilon_r = 9$ and occupying the region defined by $z \geq 0$.

(i) Write an expression for the electric field phasor of the incident wave, given that the field is a positive maximum at $z = 0$ and $t = 0$.

[5 marks]

(ii) Calculate the reflection and transmission coefficients.

[4 marks]

(iii) Write expressions for the electric phase phasors of reflected wave and the transmitted wave in the region $z \leq 0$.

[4 marks]

Question 4

(a) Compare between transmission lines and waveguides characteristics in terms of:

(i) Structure.
(ii) Operating mode.
(iii) Cut-off frequency.

[6 marks]

(b) A 2.5 cm x 1 cm rectangular waveguide is operated at frequency below 15.1 GHz. The waveguide is filled with a medium that is characterized by $\sigma = 0$, $\varepsilon_r = 4\varepsilon_0$ and $\mu_r = 1$.

Determine:

(i) The cut off frequencies of the propagating TE and TM modes.

[8 marks]

(ii) TE and TM propagating modes. Provide at least three modes for each.

[3 marks]

(c) A WR650 rectangular waveguide has an external dimension of 16.51 cm x 8.255 cm and wall thickness of 0.203 cm for wave operating at 1.5 GHz.

Calculate:

(i) Cut-off wavelength, λ_c

[1.5 marks]

(ii) Guided wavelength, λ_g.

[1.5 marks]

Continued...

(iii) Phase velocity, u_p

[1.5 marks]

(iv) Guide velocity, v_g.

[1.5 marks]

If the operating frequency is reduces to 1.2 GHz, would it affect the guided wavelength? Justify your answer.

[2 marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s
Electron rest mass	m	9.11×10^{-31} kg
Effective electron mass	m_e	$0.068m$
Effective hole mass	m_h	$0.56m$

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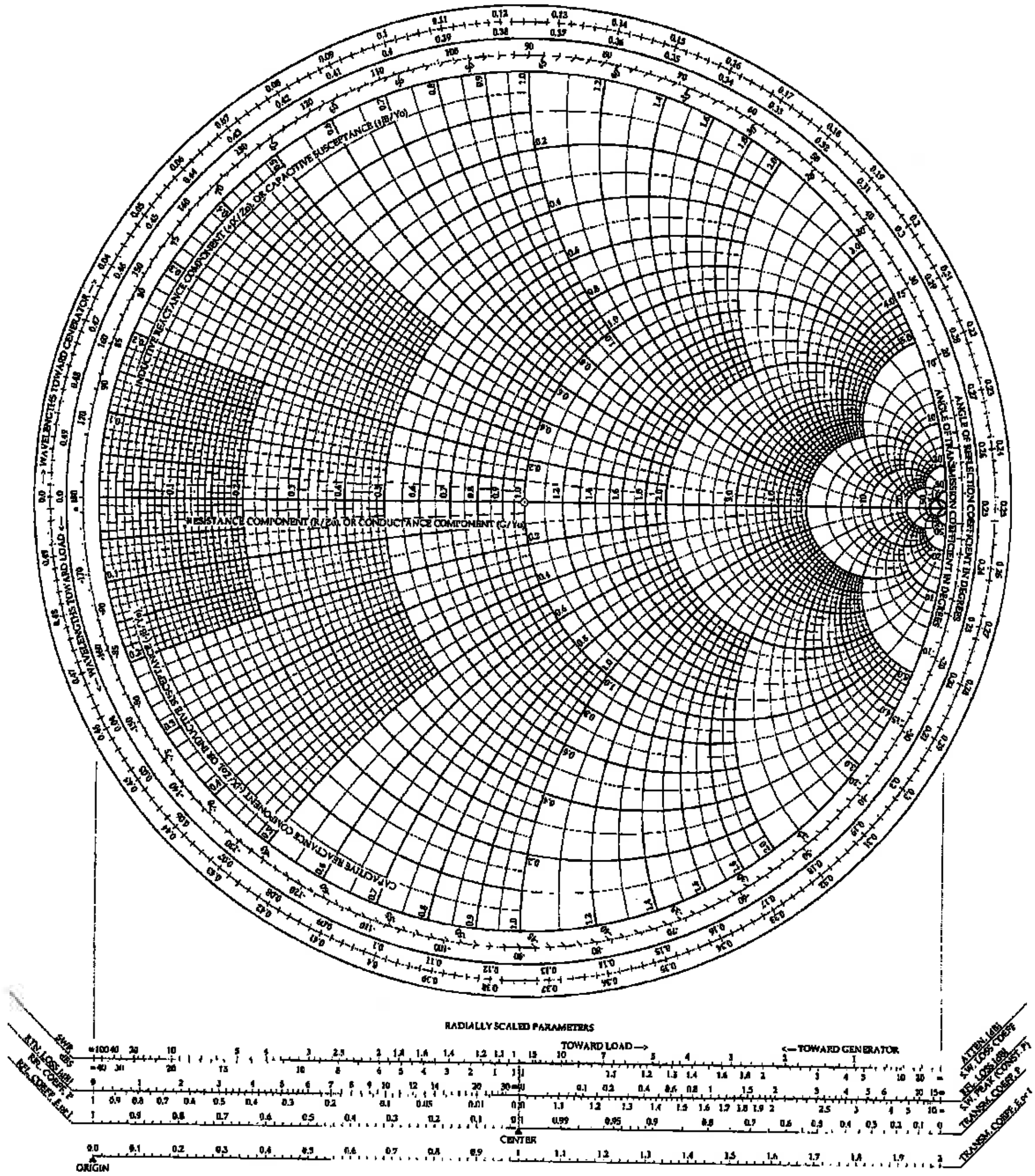
Appendix B

The Complete Smith Chart

Black Magic Design



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The Complete Smith Chart

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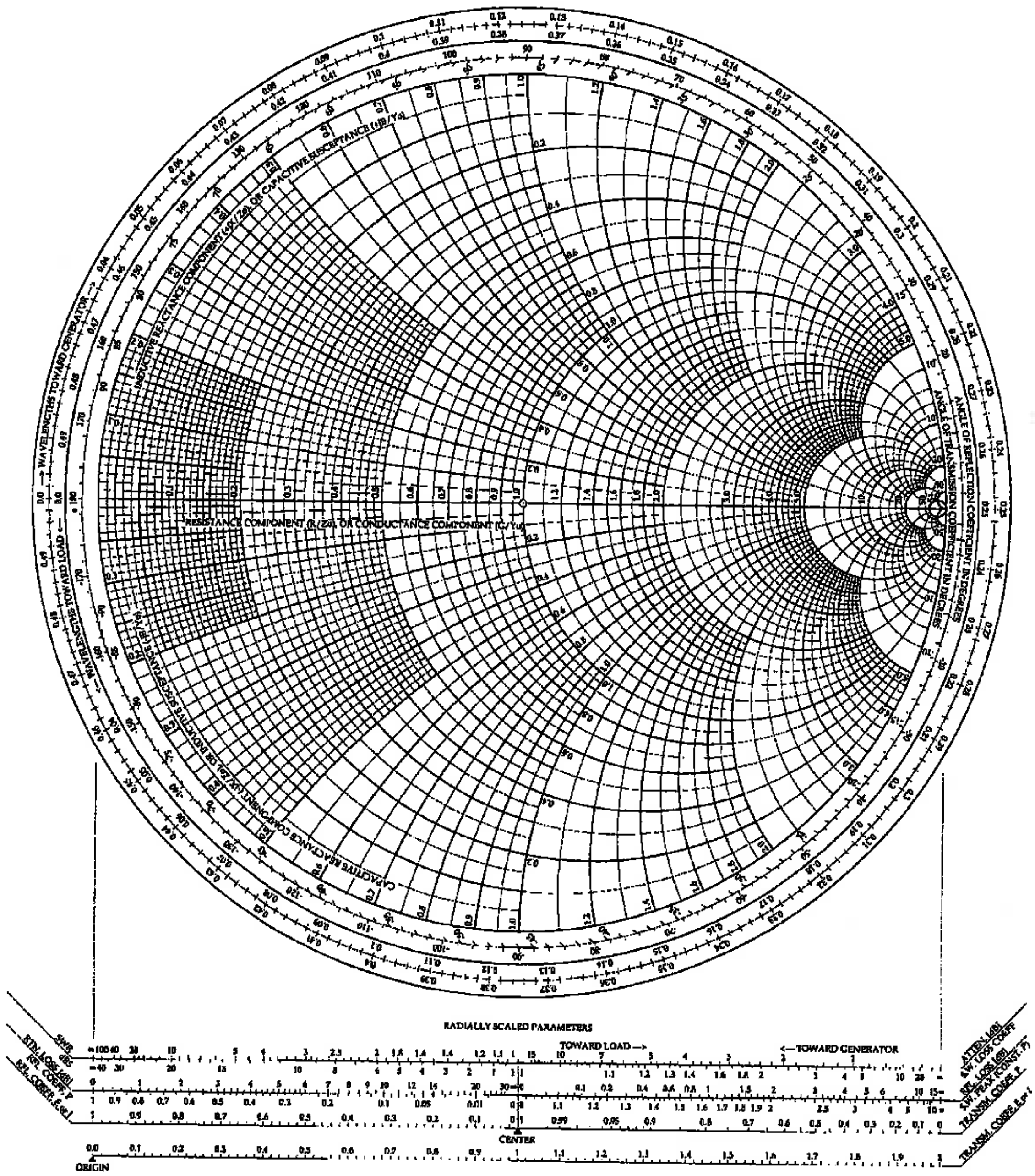

End of paper.